CHAPTER II - RECONNAISSANCE AND FIXES

1. GENERAL

The Joint Typhoon Warning Center depends on reconnaissance to provide necessary, accurate, and timely meteorological information in support of each warning. JTWC relies primarily on three reconnaissance platforms: aircraft, satellite, and radar. In data rich areas synoptic data is also used to supplement the above. Optimum utilization of all available reconnaissance resources is obtained through the Selective Reconnaissance Program (SRP), whereby various factors are considered in selecting a specific reconnaissance platform to support each warning. These factors include: cyclone location and intensity, reconnaissance platform capabilities and limitations, and the cyclone's threat to life/property afloat and ashore. A summary of reconnaissance fixes received during 1981 is included in Section 6 of this Chapter.

2. RECONNAISSANCE AVAILABILITY

a. Aircraft:

Aircraft weather reconnaissance in the JTWC area of responsibility is performed by the 54th Weather Reconnaissance Squadron (54th WRS) located at Andersen Air Force Base, Guam. Presently equipped with six WC-130 aircraft, the 54th WRS, from July through October, is augmented by the 53rd WRS from Keesler Air Force Base, Mississippi, bringing the total number of available aircraft to nine. The JTWC reconnaissance requirements, provided daily throughout the year to the Tropical Cyclone Aircraft Reconnaissance Coordinator (TCARC), include area(s) to be investigated, tropical cyclone(s) to be fixed, fix times, and forecast positions for fixes. The following priorities are utilized in acquiring meteorological data from aircraft, satellite, and land-based radar in accordance with CINCPACINST 3140.1P:

"(1) Investigative flights and vortex or center fixes for each scheduled warning in the Pacific area of responsibility. One aircraft fix per day of each cyclone of tropical storm or typhoon intensity is desirable.

(2) Supplementary fixes.

(3) Synoptic data acquisition."

As in previous years, aircraft reconnaissance provided direct measurements of height, temperature, flight-level winds, sea-level pressure, estimated surface winds (when observable), and numerous additional parameters. The meteorological data are gathered by the Aerial Reconnaissance Weather Officers (ARWO) and dropsonde operators of Detachment 4, Hq AWS, who fly with the 54th WRS. These data provide the Typhoon Duty Officer (TDO) indications of changing cyclone characteristics, radius of cyclone associated winds, and present cyclone position and intensity. Another important aspect is the availability of the data for research on tropical cyclone analysis and forecasting.

b. Satellite

Satellite fixes from USAF/USN ground sites and USN ships provide day and night coverage in the JTWC area of responsibility. Interpretation of this satellite imagery provides cyclone positions and estimates of storm intensities through the Dvorak technique (for daytime passes).

Detachment 1, 1st Weather Wing, which receives and processes polar orbiting satellite data, is the primary fix site for the western Pacific. Satellite fix positions received at JTWC from the Air Force Global Weather Central (AFGWC), Offutt Air Force Base, Nebraska and the Naval Oceanography Command Detachment at Diego Garcia were the major sources of satellite data for the Indian Ocean. GOES fixes were also provided by the National Environmental Satellite Service, Honolulu, Hawaii for tropical cyclones near the dateline.

c. Radar

Land radar provides positioning data on well developed cyclones when in the proximity (usually within 175 nm (324 km)) of the radar sites in the Republic of the Philippines, Taiwan, Hong Kong, Japan, the Republic of Korea, Kwajalein, and Guam.

d. Synoptic

In 1981, JTWC also determined tropical cyclone positions based on the analysis of the surface/gradient level synoptic data. These positions were helpful in situations where the vertical structure of the tropical cyclone was weak or accurate surface positions from aircraft were not available due to flight restrictions.

3. AIRCRAFT RECONNAISSANCE SUMMARY

During the 1981 tropical season, the JTWC levied 201 six-hourly vortex fixes and 78 investigative missions of which 21 were flown into disturbances which did not develop. In addition to the levied fixes, 106 supplemental fixes were also obtained. The number of levied investigative missions has increased steadily over the past five years in response to JTWC's increased efforts to detect initial tropical cyclone development. The average vector error for all aircraft fixes received at the JTWC during 1981 was 13 nm (24 km).

Aircraft reconnaissance effectiveness is summarized in Table 2-1 using the criteria as set forth in CINCPACINST 3140.1P.

TABLE 2-1. AIRCRAFT RECONNAISSANCE EFFECTIVENESS

EFFECTIVENESS	NUMBER OF LEVIED FIXES	PERCENT
COMPLETED ON TIME	184	91.5
EARLY	3	1.5
LATE	11	5.5
MISSED	3	1.5
TOTAL	201	100.0

LEVIED VS. MISSED FIXES

	LEVIED	MISSED	PERCENT
AVERAGE 1965-1970	507	10	2.0
1971	802	61	7.6
1972	624	126	20.2
1973	227	13	5.7
1974	358	30	8.4
1975	217	7	3.2
1976	317	11	3.5
1977	203	3	1.5
1978	290	2	0.7
1979	289	14	4.8
1980	213	4	1.9
1981	201	3	1.5

4. SATELLITE RECONNAISSANCE SUMMARY

The Air Force provides satellite reconnaissance support to JTWC using imagery data from DMSP and NOAA polar-orbiting spacecraft. In addition, geostationary satellite data is also available.

The DMSP cyclone surveillance network consists of both tactical and centralized facilities. Tactical DMSP sites are located at Nimitz Hill, Guam; Clark AB, Philippines; Kadena AB, Japan; Osan AB, Korea; and Hickam AFB, Hawaii. These sites provide a combined coverage that includes the JTWC area of responsibility in the western North Pacific from near the dateline westward to the Malay Peninsula. The Navy tactical site at Diego Garcia continues to provide NOAA polar-orbiting coverage in the central South Indian Ocean. Their reconnaissance supplements the Air Force Global Weather Central (AGWC) support in this data sparse region.

AFGWC, located at Offutt AFB, Nebraska is the centralized member of the satellite cyclone surveillance network. In support to JTWC, AFGWC processes imagery from DMSP and NOAA spacecraft. Imagery processed at AFGWC is recorded on-board the spacecraft as it passes over the earth. Later, these data are downlinked to AFGWC via a network command/readout sites and communications satellites. This enables AFGWC to obtain the coverage necessary to fix all cyclones of interest to JTWC. AFGWC has the primary responsibility to provide cyclone surveillance over the entire Indian Ocean and a small portion of the western North Pacific near the dateline. Additionally, AFGWC can be tasked to provide storm positions in the western North Pacific and South Pacific as backup to coverage routinely available in this region.

The hub of the network is Det 1, 1WW colocated with JTWC, Nimitz Hill, Guam. Based on available satellite coverage, Det 1 coordinates satellite reconnaissance requirements with JTWC and tasks the individual network sites for the necessary storm fixes. Therefore, when a position from a polar-orbiting satellite is required as the basis for a warning, called a levied fix, a dual sight tasking concept is applied. Under this concept two sites are tasked to fix the cyclone off the same satellite pass. This provides the necessary redundancy to virtually guarantee JTWC a successful satellite fix on the cyclone. Using this dual-site concept, the satellite reconnaissance network was able to meet all of JTWC's levied satellite fix requirements. Dual-site tasking is applied in the Indian Ocean as well by using AFGWC and the Navy weather detachment site at Diego Garcia.

The network provides JTWC with several products and services. The main service is one of surveillance. Each site reviews its daily satellite coverage for indications of tropical cyclone development. If an area exhibits the potential for development, JTWC is notified. Once JTWC issues either an alert or warning, the network is tasked to provide three products: cyclone positions, cyclone intensity estimates, and 24-hour cyclone intensity forecasts. Satellite cyclone positions are assigned position code numbers (PCN) depending on the availability of geography for precise gridding and the degree of organization of the cyclone's circulation center (Table 2-2). During 1981 the network provided JTWC with over 1200 satellite fixes on WESTPAC tropical disturbances. Another 110 fixes were made by Det 1 for tropical disturbances in the North Indian Ocean. A comparison of those fixes made on WESTPAC numbered tropical cyclones with their corresponding JTWC best track positions is shown in Table 2-3. Estimates of the cyclone's current intensity and a 24-hour intensity forecast are made once each day by applying the Dvorak technique (NOAA Technical Memorandum NESS 45 as revised) to daylight visual data.

The availability of polar-orbiting meteorological satellites improved since the end of 1980. At that time only NOAA 6 and F-3 (FTV 14537), both sunrise orbiters, were available. However, in June NOAA 7 was successfully launched with the network able to use visual imagery by orbit 25 and IR data by orbit number 210. NOAA 7 replaced TIROS-N and is in a mid-afternoon orbit. NOAA 6 continued to function normally throughout the year except for a brief 3

TABLE 2-2. POSITION CODE NUMBERS

PCN	METHOD OF CENTER DETERMINATION/GRIDDING
1	EYE/GEOGRAPHY
2	EYE/EPHEMERIS
3	WELL DEFINED CC/GEOGRAPHY
4	WELL DEFINED CC/EPHEMERIS
5	POORLY DEFINED CC/GEOGRAPHY
6	POORLY DEFINED CC/EPHEMERIS

CC=Circulation Center

TABLE 2-3. MEAN DEVIATION (NM) OF ALL SATELLITE DERIVED TROPICAL CYCLONE POSITIONS FROM THE JTWC BEST TRACK POSITIONS. NUMBER OF CASES IN PARENTHESIS.

PCN	WESTPAC 1974-1980 AVERAGE (ALL SITES)	WESTPAC 1981 (ALL SITES)	INDIAN OCEAN 1980 (ALL SITES)	INDIAN OCEAN 1981 (ALL SITES)
1	13.1 (269)	14.6 (159)	-	17.0 (9)
2	18.0 (80)	16.6 (5)	-	9.5 (2)
3	20.5 (435)	17.5 (217)	-	29.7 (6)
4	23.8 (107)	38.3 (13)	-	-
5	38.1 (725)	35.2 (789)	35.7 (8)	29.9 (14)
6	42.6 (278)	55.1 (39)	44.6 (12)	32.7 (21)
1&2	14.2 (349)	14.7 (164)	-	15.6 (11)
3&4	21.2 (542)	18.7 (230)	-	29.7 (6)
5&6	39.3 (1003)	36.1 (828)	41.0 (20)	31.6 (35)

week period in August and September. During that time a data anomaly developed rendering the visual and IR data unusable. However, the problem corrected itself and despite over 13,000 orbits by the end of 1981, the spacecraft is functioning normally. While most network sites use NOAA 6 on a routine basis, Det 1 now uses NOAA 7 as its primary surveillance and reconnaissance satellite. Higher sun angle giving clearer visual imagery and more timely nodal crossings makes NOAA 7 more conducive to Det 1 operations. On the DMSP side, no new launches were attempted in 1981. F-3 is still providing ascending daylight coverage despite 19,000 orbits. In summary, NOAA 6, NOAA 7 and F-3 were being used at years end.

Besides fixes from the network, JTWC also received satellite-derived cyclone positions from several secondary sources during 1981. These included: U. S. Navy ships equipped for direct readout; the National Environmental Satellite Service (NESS) using NOAA and GOES data; and the Naval Polar Oceanography Center, Suitland, Maryland using stored DMSP and NOAA data. Fixes from these secondary sources are not included in the network statistics.

5. RADAR RECONNAISSANCE SUMMARY

Seventeen of the 29 significant tropical cyclones occurring over the western North Pacific during 1981 passed within range of land based radars with sufficient cloud pattern organization to be fixed. The hourly and oftentimes, half-hourly land radar fixes that were obtained and transmitted to JTWC totaled 584.

The WMO radar code defines three categories of accuracy: good (within 10 km (5.4 nm)), fair within 10-30 km (5.4-16.2 nm)), and poor (within 30-50 km (16.2-2.27 nm)). This year, 584 radar fixes were coded in this manner; 254 were good, 172 fair, and 158 poor. Compared to the JTWC best track, the mean vector deviation for land radar sites was 18 nm (33 km). Excellent support through timely and accurate radar fix positioning allowed JTWC to track and forecast tropical cyclone movement through even the most difficult and erratic tracks.

No radar fixes were made by 54th WRS aircraft during the WESTPAC tropical cyclone season and, as in previous years, no radar reports were received on Indian Ocean cyclones.

6. TROPICAL CYCLONE FIX DATA

A total of 2230 fixes on 29 northwest Pacific tropical cyclones and 111 fixes on 3 northern Indian Ocean tropical cyclones were received at JTWC. Table 2-4, Fix Platform Summary, delineates the number of fixes per platform for each individual tropical cyclone. Season totals and percentages are also indicated.

Annex A includes individual fix data for each tropical cyclone. Fix data are divided into four categories: Satellite, Aircraft, Radar, and Synoptic. Those fixes labelled with an asterisk (*) were determined to be unrepresentative of the surface center and were not used in determining the best tracks. Within each category, the first three columns are as follows:

FIX NO. - Sequential fix number

TIME (Z) - GMT time in day, hours and minutes

FIX POSITION - Latitude and longitude to the nearest tenth of a degree

Depending upon the category, the remainder of the format varies as follows:

a. Satellite

(1) ACCRY - Position Code Number (PCN) is used to indicate the accuracy of the fix position. A "1" indicates relatively high accuracy and a "6" relatively low accuracy.

(2) DVORAK CODE - Intensity evaluation and trend utilizing visual satellite data. (For specifics, refer to NOAA TM; NESS-45) (Table 2-5).

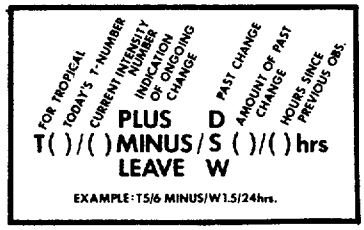

TABLE 2-4. FIX SUMMARY FOR 1981

FIX SUMMARY

	AIRCRAFT	DMSP	NOAA 6&7	OTHER SAT	RADAR	SYNOPTIC	TOTAL
WESTERN PACIFIC							
TY FREDA	11	1	10	28	0	4	54
TS GERALD	17	1	12	37	10	0	77
TS HOLLY	22	2	20	48	0	0	92
TS IKE	1	1	14	39	3	2	60
TY JUNE	11	0	18	35	23	0	87
TY KELLY	7	0	24	32	7	1	71
TS LYNN	4	0	18	28	78	6	134
TS MAURY	3	0	9	8	0	11	31
TS NINA	0	0	5	7	0	3	15
TY OGDEN	11	0	11	23	73	0	118
TD 11	0	0	5	10	0	3	18
TS PHYLLIS	3	0	4	14	0	0	21
TS ROY	5	0	17	31	4	0	57
TS SUSAN	2	0	16	32	0	0	50
TY THAD	26	2	16	42	9	11	106
TS VANESSA	2	0	2	19	0	0	23
TS WARREN	0	0	5	19	0	1	25
TY AGNES	17	1	16	49	140	2	225
TY BILL	12	0	9	26	0	0	47
TY CLARA	19	0	18	42	45	0	124
TY DOYLE	0	0	10	26	0	0	36
ST ELSIE	29	1	20	47	9	1	107
TS FABIAN	1	0	7	12	0	2	22
TY GAY	30	0	24	43	49	1	147
TY HAZEN	19	0	17	53	50	2	141
ST IRMA	18	0	20	50	70	13	171
TS JEFF	9	0	7	33	1	0	50
TY KIT	32	0	30	43	2	0	108
TY LEE	12	0	11	38	11	0	72
TOTAL	324	9	395	914	584	63	2289
% OF TOTAL NO. OF FIXES	14.2	0.4	17.3	39.9	25.5	2.7	100

	NOAA 6&7	OTHER	SYNOPTIC	TOTAL
INDIAN OCEAN				
TC 27-81	27	0	0	27
TC 29-81	18	16	0	34
TC 31-81	23	26	0	49
TOTAL	68	42	0	110
% OF TOTAL NO. OF FIXES	61.8	38.2		100

TABLE 2-5. MAXIMUM SUSTAINED WIND SPEED (KT) AS A FUNCTION OF DVORAK T NUMBER AND MINIMUM SEA LEVEL PRESSURE (MSLP)

TROPICAL CYCLONE INTENSITY	WIND SPEED	MSLP (NW PACIFIC)
T 1.0	25	--
T 1.5	25	--
T 2.0	30	1003
T 2.5	35	999
T 3.0	45	994
T 3.5	55	988
T 4.0	65	981
T 4.5	77	973
T 5.0	90	964
T 5.5	102	954
T 6.0	115	942
T 6.5	127	929
T 7.0	140	915
T 7.5	155	900
T 8.0	170	884

(3) SAT - Specific satellite used for fix position (DMSP 37 or NOAA 6, NOAA 7, or Other).

(4) COMMENTS - For explanation of abbreviations, see Appendix.

(5) SITE - ICAO call sign of the specific satellite tracking station.

b. Aircraft

(1) FLT LVL - The constant pressure surface level, in mb, maintained during the penetration. Seven hundred mb is the normal level flown in developed cyclones due to turbulence factors. Low-level missions are flown at 1500 ft.

(2) 700 MB HGT - Minimum height of the 700 mb pressure surface within the vortex recorded in meters.

(3) OBS MSLP - If the surface center can be visually detected (e.g., in the eye), the minimum sea-level pressure is obtained by a dropsonde released above the surface vortex center. If the fix is made at the 1500-foot level, the sea-level pressure is extrapolated from that level.

(4) MAX-SFC-WND - The maximum surface wind (knots) is an estimate made by the ARWO based on sea state. This observation is limited to the region of the flight path and may not be representative of the entire cyclone. Availability of data is also dependent upon the absence of undercast conditions and the presence of adequate illumination. The positions of the maximum flight level wind and the maximum observed surface wind do not necessarily coincide.

(5) MAX-FLT-LVL-WND - Wind speed (knots) at flight level is measured by the AN/APN 147 doppler radar system aboard the WC-130 aircraft. Values entered in this category represent the maximum wind measured prior to obtaining a scheduled fix. This measurement may not represent the maximum flight level wind associated with the tropical cyclone because the aircraft only samples those portions of the tropical cyclone along the flight path. In most instances, the flight path is through the weak sector of the cyclone. In areas of heavy rainfall, the doppler radar may track energy reflected from precipitation rather than from the sea surface, thus, preventing accurate wind speed measurement. In obvious cases, such erroneous wind data will not be reported. In addition, the doppler radar system on the WC-130 restricts wind measurements to drift angles less than or equal to 27 degrees if the wind is normal to the aircraft heading.

(6) ACCRY - Fix position accuracy. Both navigational (OMEGA and LORAN) and meteorological (by the ARWO) estimates are given in nautical miles.

(7) EYE SHAPE - Geometrical representation of the eye based on the aircraft radar presentation. The eye shape is reported only if the center is 50% or more surrounded by wall cloud.

(8) EYE DIAM/ORIENTATION - Diameter of the eye in nautical miles. In case of an elliptical eye, the lengths of the major and minor axes and the orientation of the major axis are respectively listed. In the case of concentric eye walls, both diameters are listed.

c. Radar

(1) RADAR - Specific type of platform utilized for fix (land radar site, aircraft, or ship).

(2) ACCRY - Accuracy of fix position (good, fair, or poor) as given in the WMO ground radar weather observation code (FM20-V)

(3) EYE SHAPE - Geometrical representation of the eye given in plain language (circular, elliptical, etc.).

(4) EYE DIAM - Diameter of eye given in kilometers.

(5) RADOB CODE - Taken directly from WMO ground weather radar observation code FM20-V. The first group specifies the vortex parameters, while the second group describes the movement of the vortex center.

(6) RADAR POSITION - Latitude and longitude of tracking station given in tenths of a degree.

(7) SITE - WMO station number of the specific tracking station.

d. Synoptic

(1) INTENSITY ESTIMATE - TDO's analysis of low-level synoptic data to determine a cyclone's maximum sustained surface wind (knots).

(2) NEAREST DATA - Accuracy of fix based on distance (nautical miles) from the fix position to the nearest synoptic report or to the average distance of reports in data sparse cases.